PART – A (PAPER-1)_CHEMISTRY

SECTION 1 (Maximum Marks : 12)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme:

  Full Marks : +3 If **ONLY** the correct option is chosen;
  Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
  Negative Marks : -1 In all other cases.

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1. A closed vessel contains 10 g of an ideal gas X at 300 K, which exerts 2 atm pressure. At the same temperature, 80 g of another ideal gas Y is added to it and the pressure becomes 6 atm. The ratio of root mean square velocities of X and Y at 300 K is

(A) $2\sqrt{2}:\sqrt{3}$ (B) $2\sqrt{2}:1$ (C) 1 : 2 (D) 2 : 1

Ans. **(D)**

Sol. Given,

$Wx = 10\,\text{g}$

$P_x = 2\,\text{atm}$

$W_Y = 80\,\text{g}$

$P_Y = P_{\text{total}} - P_X$

$\Rightarrow 6 - 2 = 4\,\text{atm}$

$$\text{As } V_{\text{rms}} = \sqrt{\frac{3RT}{M}},$$

$$\frac{(V_{\text{rms}})_X}{(V_{\text{rms}})_Y} = \sqrt{\frac{M_Y}{M_X}}$$

As we know,

P V=n R T

Volume and temperature remains same.

$$P_X V = \frac{W_X}{M_X} RT$$

$$P_Y V = \frac{W_Y}{M_Y} RT$$

$$M_X \propto \frac{W_X}{P_X}$$

$$M_Y \propto \frac{W_Y}{P_Y}$$

$$\frac{(V_{rms})_X}{(V_{rms})_Y} = \sqrt{\frac{W_Y}{P_Y} \cdot \frac{P_X}{W_X}} = \sqrt{\frac{80}{4} \times \frac{2}{10}} = \sqrt{4} = \frac{2}{1} = 2:1$$

2. At room temperature, disproportionation of an aqueous solution of in situ generated nitrous acid (HNO_2) gives the species

(A) H_3O^+, NO_3^- and NO (B) H_3O^+, NO_3^- and NO_2

(C) H_3O^+, NO^- and NO_2 (D) H_3O^+, NO_3^- and N_2O

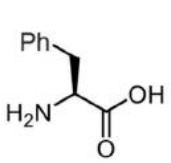
Ans. **(A)**

Sol. $\underset{+3}{3HNO_2} \rightleftharpoons \underset{+5}{HNO_3} + \underset{+1}{2NO} + H_2O$

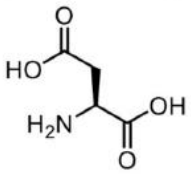
H_3O^+, NO_3^- and NO

3. Aspartame, an artificial sweetener, is a dipeptide aspartyl phenylalanine methyl ester. The structure of aspartame is

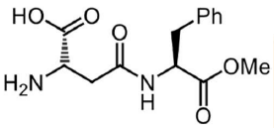
Structures of phenylalanine and aspartic acid are given below.

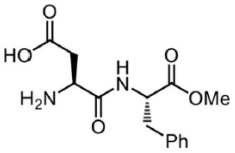


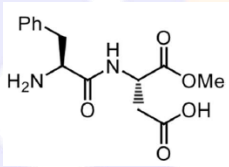
Phenylalanine

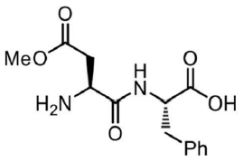


Aspartic acid

(A) 

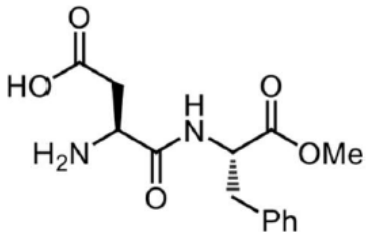
(B) 

(C) 

(D) 

Ans. **(B)**

Sol. Aspartame is



4. Among the following options, select the option in which each complex in Set-I shows geometrical isomerism and the two complexes in Set-II are ionization isomers of each other.

[en $= H_2NCH_2CH_2NH_2$]

(A) Set-I: $\left[Ni(CO)_4\right]$ and $\left[PdCl_2\left(PPh_3\right)_2\right]$

Set-II: $\left[Co\left(NH_3\right)_5Cl\right]SO_4$ and $\left[Co\left(NH_3\right)_5\left(SO_4\right)\right]Cl$

(B) Set-I: $\left[Co(en)\left(NH_3\right)_2Cl_2\right]$ and $\left[PdCl_2\left(PPh_3\right)_2\right]$

Set-II: $\left[Co\left(NH_3\right)_6\right]\left[Cr(CN)_6\right]$ and $\left[Cr\left(NH_3\right)_6\right]\left[Co(CN)_6\right]$

(C) Set-I: $\left[Co\left(NH_3\right)_3\left(NO_2\right)_3\right]$ and $\left[Co(en)_2Cl_2\right]$

Set-II: $\left[Co\left(NH_3\right)_5Cl\right]SO_4$ and $\left[Co\left(NH_3\right)_5\left(SO_4\right)\right]Cl$

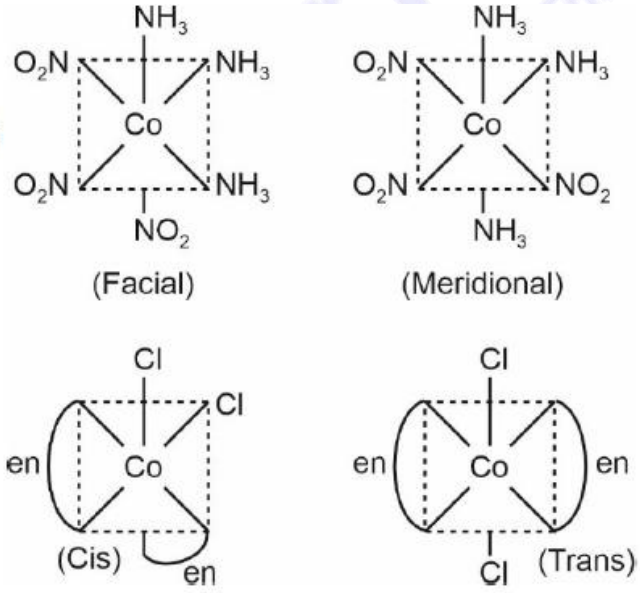
(D) Set-I: $\left[Cr\left(NH_3\right)_5Cl\right]Cl_2$ and $\left[Co(en)\left(NH_3\right)_2Cl_2\right]$

Set – II : $\left[Cr\left(H_2O\right)_6\right]Cl_3$ and $\left[Cr\left(H_2O\right)_5Cl\right]Cl_2\cdot H_2O$

Ans. **(C)**

Sol.

Set-I:



Set – II : $\left[Co\left(NH_3\right)_5Cl\right]SO_4$ and $\left[Co\left(NH_3\right)_5SO_4\right]Cl$ are ionisation isomers.

SECTION 2 (Maximum Marks : 12)

- This section contains **THREE (03)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +4 **ONLY** if (all) the correct option(s) is(are) chosen;
Partial Marks : +3 If all the four options are correct but **ONLY** three options are chosen;
Partial Marks : + 2 If three or more options are correct but **ONLY** two options are chosen, both of which are correct;
Partial Marks : +1 If two or more options are correct but **ONLY** one option is chosen and it is a correct option;
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
Negative Marks : –2 In all other cases.

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5. Among the following the correct statement(s) for electrons in an atom is(are)
(A) Uncertainty principle rules out the existence of definite paths for electrons.
(B) The energy of an electron in 2s orbital of an atom is lower than the energy of an electron that is infinitely far away from the nucleus.
(C) According to Bohr's model, the most negative energy value for an electron is given by n=1, which corresponds to the most stable orbit.
(D) According to Bohr's model, the magnitude of velocity of electrons increases with increase in values of n..

Ans. **(A, B, C)**

Sol. (A) Uncertainty principle rules out existence of definite paths or trajectories of electron and other similar particles So, option (A) is correct.

(B) Shell or orbit more near to nucleus has less energy than faraway.

So, option (B) is also correct.

(C) $E=-13.6\frac{Z^2}{n^2}eV$ / atom

So, $n=1$ has most negative energy.

So, option (C) is also correct.

(D) $V=V_0\times\frac{Z}{n}$

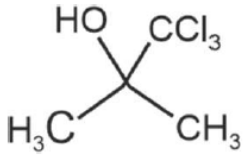
when n increases velocity decreases.

So, option (D) is incorrect.

6. Reaction of iso-propylbenzene with O_2 followed by the treatment with H_3O^+ forms phenol and a by-product $\mathbf{P}$. Reaction of $\mathbf{P}$ with 3 equivalents of Cl_2 gives compound $\mathbf{Q}$. Treatment of $\mathbf{Q}$ with $Ca(OH)_2$ produces compound $\mathbf{R}$ and calcium salt $\mathbf{S}$.

The correct statement(s) regarding $\mathbf{P}, \mathbf{Q}, \mathbf{R}$ and $\mathbf{S}$ is(are)

(A) Reaction of $\mathbf{P}$ with $\mathbf{R}$ in the presence of KOH followed by acidification gives



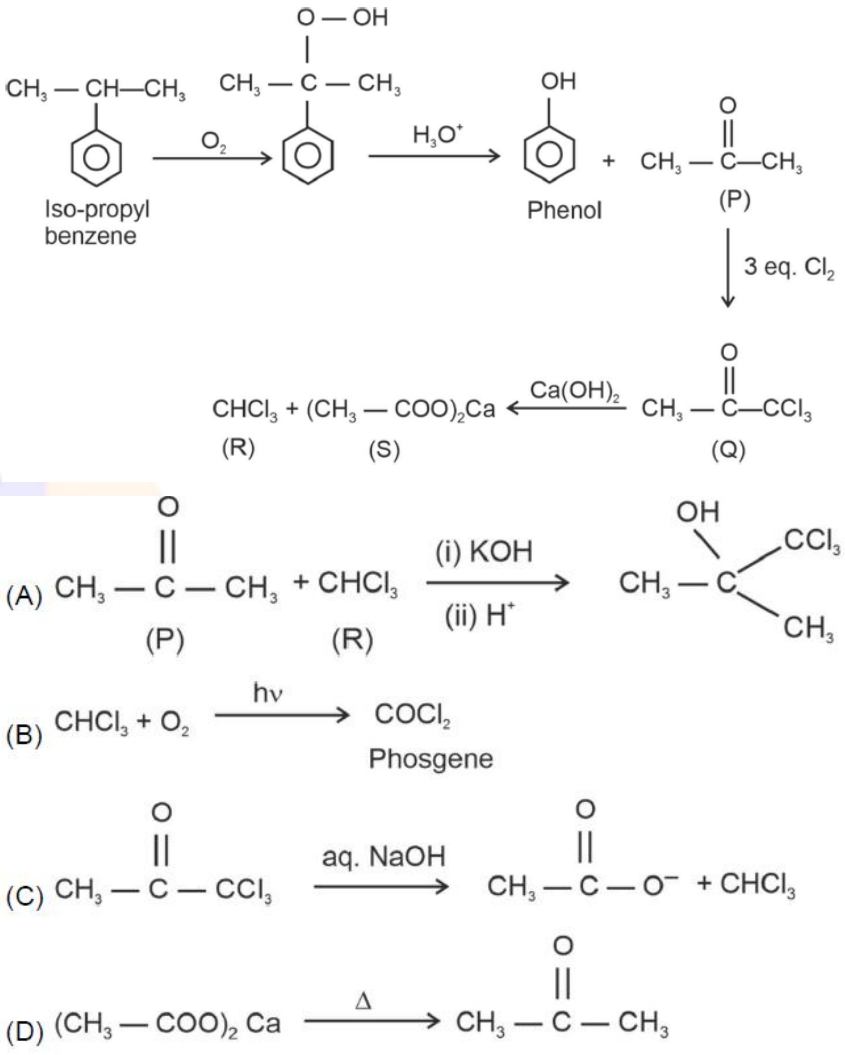
(B) Reaction of $\mathbf{R}$ with O_2 in the presence of light gives phosgene gas

(C) Q reacts with aqueous $NaOH$ to produce Cl_3CCH_2OH and $Cl_3CCOONa$

(D) S on heating gives P

Ans. **(A, B, D)**

Sol.



7. The option(s) in which at least three molecules follow Octet Rule is(are)

(A) CO_2, C_2H_4, NO and HCl (B) NO_2, O_3, HCl and H_2SO_4

(C) BCl_3, NO, NO_2 and H_2SO_4 (D) CO_2, BCl_3, O_3 and C_2H_4

Ans. **(A,D)**

Sol. (A) CO_2, C_2H_4 and HCl follow octet rule.

(B) O_3 and HCl and follow octet rule.

(C) None of them follow octet rule.

(D) CO_2, O_3 and C_2H_4 follow octet rule.

Correct answer is (A) and (D)

SECTION 3 (Maximum Marks : 24)

- This section contains **SIX (06)** questions.
- The answer to each question is a **NON-NEGATIVE INTEGER**.
- For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +4 If **ONLY** the correct integer is entered;
Zero Marks : 0 In all other cases.

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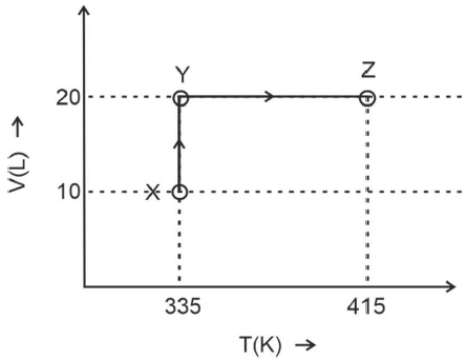
8. Consider the following volume-temperature $(V-T)$ diagram for the expansion of 5 moles of an ideal monoatomic gas.



Considering only $P-V$ work is involved, the total change in enthalpy (in Joule) for the transformation of state in the sequence $X \rightarrow Y \rightarrow Z$ is

[Use the given data: Molar heat capacity of the gas for the given temperature range, $C_{V,m} = 12\,J\,K^{-1}\,mol^{-1}$ and gas constant, $R = 8.3\,J\,K^{-1}\,mol^{-1}$]

Ans. **(8120)**

Sol. $X \rightarrow Y$ is an isothermal process an ideal gas:

$\Delta H = 0$

$Y \rightarrow Z$ is an isochoric process

$\therefore w = 0$

$\Delta U = nC_{v,m}\left(T_2 - T_1\right)$

$= 5 \times 12(415 - 335)$

$= 4800\,J$

$\Delta H = \Delta U + \Delta(PV)$

$= \Delta U + nR\Delta T$

$= 4800 + 5 \times 8.3 \times (415 - 335)$

$= 8120\,J$

9. Consider the following reaction,

$2H_2(g) + 2NO(g) \rightarrow N_2(g) + 2H_2O(g)$

which follows the mechanism given below:

$2NO(g) \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} [k_{-1}]k_1\, N_2O_2(g)$ (fast equilibrium)

$N_2O_2(g) + H_2(g) \xrightarrow{k_2} N_2O(g) + H_2O(g)$ (slow reaction)

$N_2O(g) + H_2(g) \xrightarrow{k_3} N_2(g) + H_2O(g)$ (fast reaction)

The order of the reaction is _____?

Ans. **(3)**

Sol. Rate of reaction (according to slowest step)

$\Rightarrow r = k_2\left[N_2O_2\right]\left[H_2\right]$

Now for intermediate $\left[N_2O_2\right]$,

$\frac{k_1}{k_{-1}} = \frac{\left[N_2O_2\right]}{[NO]^2}$

$\Rightarrow \left[N_2O_2\right] = \frac{k_1}{k_{-1}}[NO]^2$

from equation (1) and (2)

$r = \frac{k_2k_1}{k_{-1}}[NO]^2\left[H_2\right]$

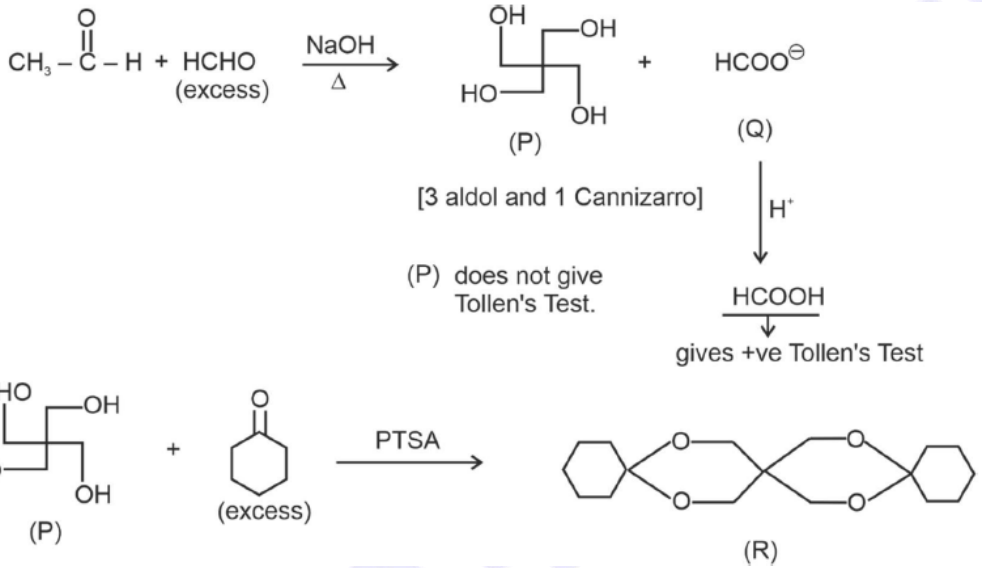
Overall order of reaction $= 2 + 1 = 3$

10. Complete reaction of acetaldehyde with excess formaldehyde, upon heating with conc. $NaOH$ solution, gives $\mathbf{P}$ and $\mathbf{Q}$. Compound $\mathbf{P}$ does not give Tollens' test, whereas $\mathbf{Q}$ on acidification gives positive Tollens' test. Treatment of P with excess cyclohexanone in the presence of catalytic amount of p-toluenesulfonic acid (PTSA) gives product R.

Sum of the number of methylene groups $\left(-CH_2-\right)$ and oxygen atoms in $\mathbf{R}$ is .

Ans. **(18)**

Sol.



Number of CH_2 groups in R = 14

Number of O-atoms = 4

Required Answer = 14 + 4 = 18

11. Among $V(CO)_6, Cr(CO)_5, Cu(CO)_3, Mn(CO)_5, Fe(CO)_5, \left[Co(CO)_3\right]^{3-}, \left[Cr(CO)_4\right]^{4-}$, and $Ir(CO)_3$, the total number of species isoelectronic with $Ni(CO)_4$ is

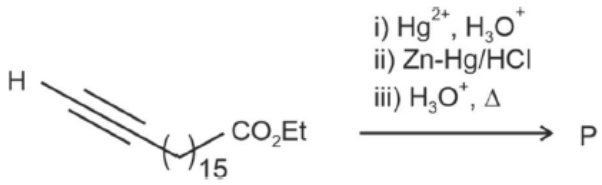
[Given atomic number : $V=23, Cr,=24, Mn=25, Fe=26, Co=27, Ni=28, Cu=29, Ir=77$]

Ans. **(1)**

Sol. Total number of electron in $Ni(CO)_4=84$

Species		**Total electron**
$V(CO)_6$	–	107
$Cr(CO)_5$	–	94
$Cu(CO)_3$	–	71
$Mn(CO)_5$	–	95
$Fe(CO)_5$	–	96
$[Co(CO)_3]^{3-}$	–	72
$[Cr(CO)_4]^{4-}$	–	84
$Ir(CO)_3$	–	119

12. In the following reaction sequence, the major product P is formed.

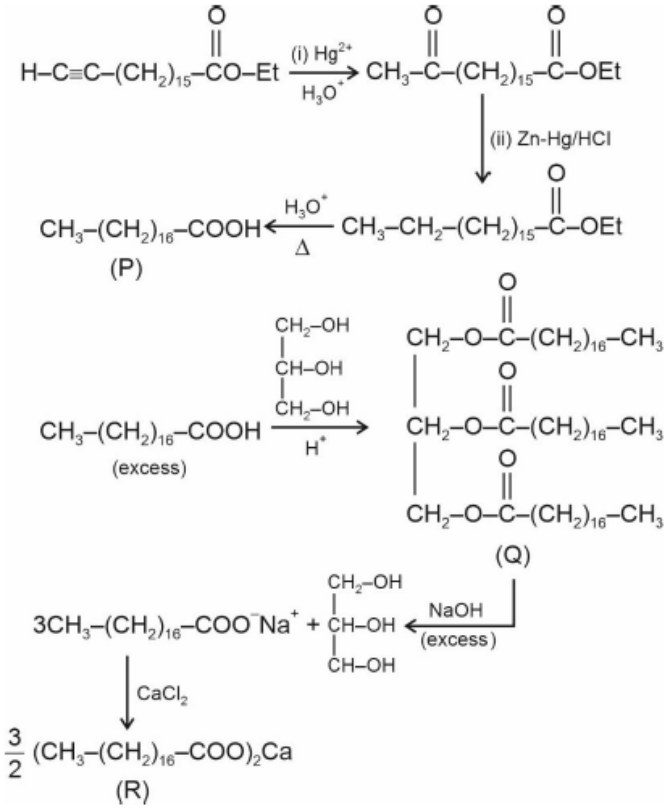


Glycerol reacts completely with excess $\mathbf{P}$ in the presence of an acid catalyst to form $\mathbf{Q}$. Reaction of $\mathbf{Q}$ with excess NaOH followed by the treatment with $\mathrm{CaCl_2}$ yields Ca -soap R, quantitatively. Starting with one mole of Q, the amount of $\mathbf{R}$ produced in gram is

[Given, atomic weight: $\mathrm{H=1, C=12, N=14, O=16, Na=23, Cl=35, Ca=40}$]

Ans. (909)

Sol.



1 mole of Q will give 1.5 mole of R.

So, mass of R produced = 606 g × 1.5

= 909

13. Among the following complexes, the total number of diamagnetic species is _____.

$\left[\mathrm{Mn(NH_3)_6}\right]^{3+}, \left[\mathrm{MnCl_6}\right]^{3-}, \left[\mathrm{FeF_6}\right]^{3-}, \left[\mathrm{CoF_6}\right]^{3-}, \left[\mathrm{Fe(NH_3)_6}\right]^{3+}$ and $\left[\mathrm{Co(en)_3}\right]^{3+}$

[Given, atomic number: $\mathrm{Mn=25, Fe=26, Co=27}$; en $=\mathrm{H_2NCH_2CH_2NH_2}$]

Ans. (1)

Sol. $\left[Mn\left(NH_3\right)_6\right]^{3+}$: Paramagnetic

$\left[MnCl_6\right]^{3-}$: Paramagnetic

$\left[FeF_6\right]^{3-}$: Paramagnetic

$\left[CoF_6\right]^{3-}$: Paramagnetic

$\left[Fe\left(NH_3\right)_6\right]^{3+}$: Paramagnetic

$\left[Co(en)_3\right]^{3+}$: Diamagnetic

Only 1 complex is diamagnetic.

SECTION 4 (Maximum Marks : 12)

- This section contains **FOUR (04)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists: **List-I** and **List-II**.
- **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- **FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated according to the following marking scheme:

  Full Marks : +3 **ONLY** if the option corresponding to the correct combination is chosen;
  Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
  Negative Marks : -1 In all other cases.

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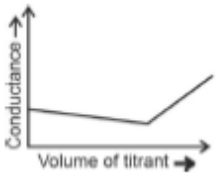
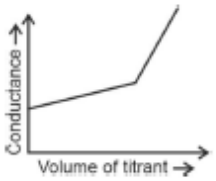
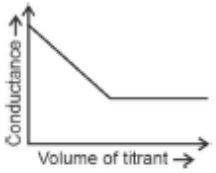
14. In a conductometric titration, small volume of titrant of higher concentration is added stepwise to a larger volume of titrate of much lower concentration, and the conductance is measured after each addition.

The limiting ionic conductivity $\left(\Lambda_0\right)$ values (in $mSm^2\,mol^{-1}$) for different ions in aqueous solutions are given below:

Ions	Ag^+	K^+	Na^+	H^+	NO_3^-	Cl^-	SO_4^{2-}	OH^-	CH_3COO^-
Λ_0	6.2	7.4	5.0	35.0	7.2	7.6	16.0	19.9	4.1

For different combinations of titrates and titrants given in List-I, the graphs of 'conductance' versus 'volume of titrant' are given in List-II.

Match each entry in List-I with the appropriate entry in List-II and choose the correct option.

	List-I		List-II
(P)	Titrate: KCl Titrant: $AgNO_3$	(1)	
(Q)	Titrate: $AgNO_3$ Titrant: KCl	(2)	
(R)	Titrate: NaOH Titrant: HCl	(3)	
(S)	Titrate: NaOH Titrant: CH_3COOH	(4)	
		(5)	

(A) P-4, Q-3, R-2, S-5 (B) P-2, Q-4, R-3, S-1

(C) P-3, Q-4, R-2, S-5 (D) P-4, Q-3, R-2, S-1

Ans. **(C)**

Sol. (P) $KCl + AgNO_3 \longrightarrow AgCl\downarrow + KNO_3$

Cl^- is replaced by NO_3^-

Conductance will first decrease and then after equivalence point, it will increase

$P \longrightarrow 3$

(Q) $AgNO_3 + KCl \longrightarrow AgCl + KNO_3$

Ag^+ is replaced by K^+

Conductance will first increase slightly and then will increase further

(R) $NaOH + HCl \longrightarrow NaCl + H_2O$

OH^- is replaced by Cl^-

(S) $NaOH + CH_3COOH \longrightarrow CH_3CCONa + H_2OOH^-$ is replaced by CH_3COO^- conductance will first decrease and them become almost constant due to buffer formation.

15. Based on VSEPR model, match the xenon compounds given in List-I with the corresponding. geometries and the number of lone pairs on xenon given in List-II and choose the correct option.

	List-I		List-II
(P)	XeF_2	(1)	Trigonal bipyramidal and two lone pair of electrons
(Q)	XeF_4	(2)	Tetrahedral and one lone pair of electrons
(R)	XeO_3	(3)	Octahedral and two lone pair of electrons
(S)	XeO_3F_2	(4)	Trigonal bipyramidal and no lone pair of electrons
		(5)	Trigonal bipyramidal and three lone pair of electrons

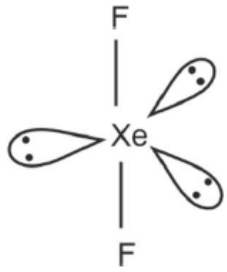
(A) P-5, Q-2, R-3, S-1 (B) P-5, Q-3, R-2, S-4

(C) P-4, Q-3, R-2, S-1 (D) P-4, Q-2, R-5, S-3

Ans. **(B)**

Sol.

XeF_2 :

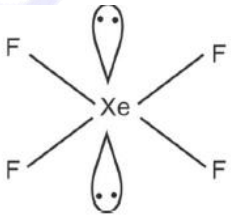


Hybridisation – sp^3d

Geometry:-

Trigonal bipyramidal and three lone pair of electrons

XeF_4 :

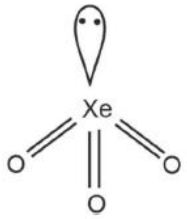


Hybridisation – sp^3d^2

Geometry:-

Octahedral and two lone pair of electrons.

XeO_3 :

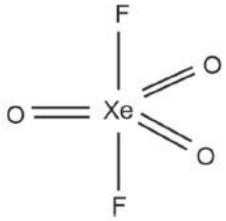


Hybridisation - sp^3

Geometry :-

tatrahedral & one lone pair of electrons.

XeO_3F_2 :



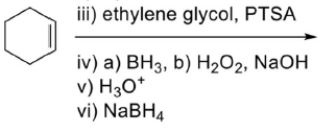
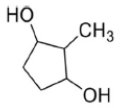
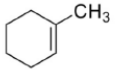
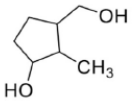
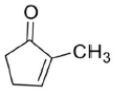
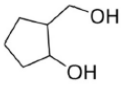
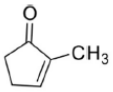
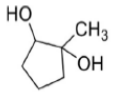
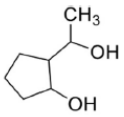
Hybridisation - sp^3d

Geometry :-

Trigonal bipyramidal and no lone pair of electrons.

Correct match : P $\rightarrow$ 5; Q $\rightarrow$ 3; R $\rightarrow$ 2; S $\rightarrow$ 4

16. List-I contains various reaction sequences and List-II contains the possible products. Match each entry in List-I with the appropriate entry in List-II and choose the correct option.

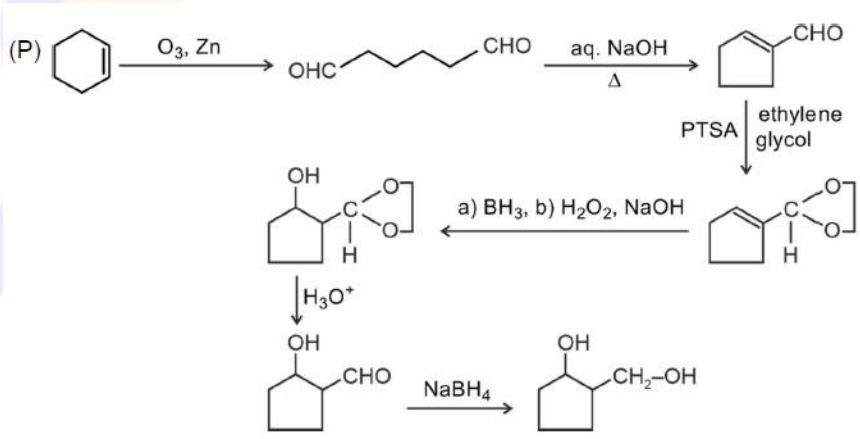
	List-I		List-II
(P)	 i) O_3, Zn ii) aq. NaOH, Δ iii) ethylene glycol, PTSA iv) a) BH_3, b) H_2O_2, NaOH v) H_3O^+ vi) $NaBH_4$	(1)	
(Q)	 i) O_3, Zn ii) aq. NaOH, Δ iii) ethylene glycol, PTSA iv) a) BH_3, b) H_2O_2, NaOH v) H_3O^+ vi) $NaBH_4$	(2)	
(R)	 i) ethylene glycol, PTSA ii) a) $Hg(OAc)_2$, H_2O, b) $NaBH_4$ iii) H_3O^+ iv) $NaBH_4$	(3)	
(S)	 i) ethylene glycol, PTSA ii) a) BH_3, b) H_2O_2, NaOH iii) H_3O^+ iv) $NaBH_4$	(4)	
		(5)	

(A) P-3, Q-5, R-4, S-1 (B) P-3, Q-2, R-4, S-1

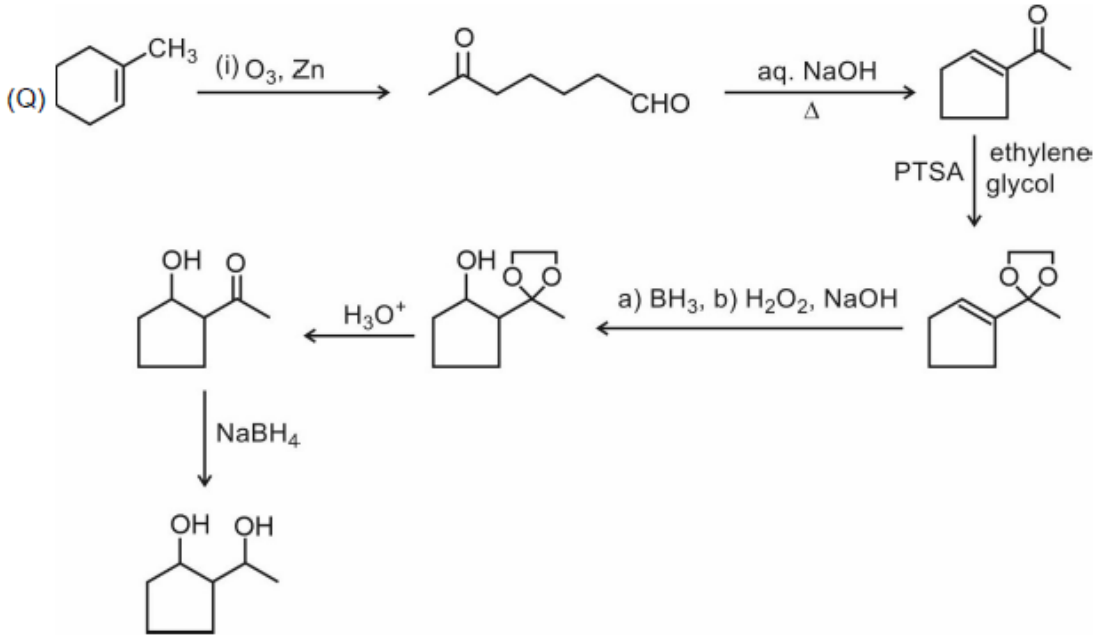
(C) P-3, Q-5, R-1, S-4 (D) P-5, Q-2, R-4, S-1

Ans. **(A)**

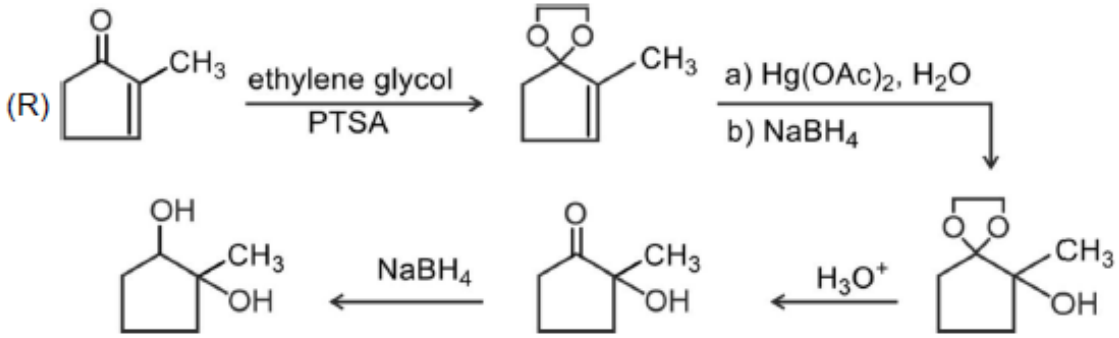
Sol.



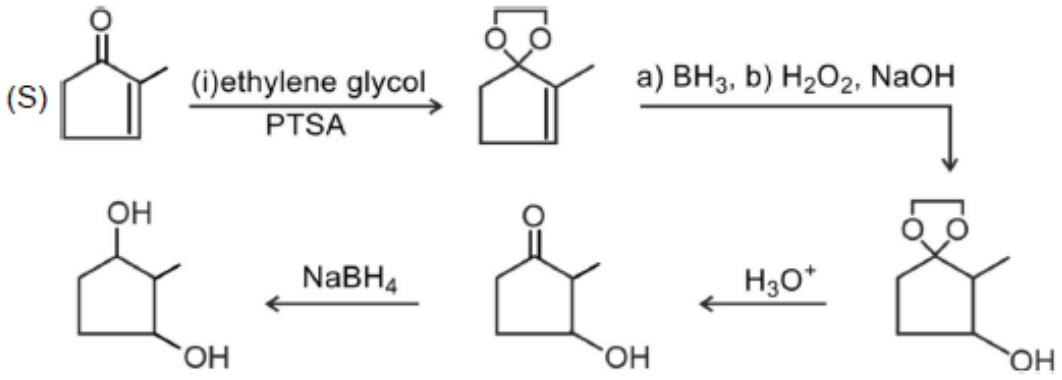
P-3


(Q)
CH3
(i) O3, Zn
O
CHO
aq. NaOH
Δ
O
PTSA
ethylene glycol
OH
O
H3O+
OH
a) BH3, b) H2O2, NaOH
NaBH4
OH
OH

Q-5

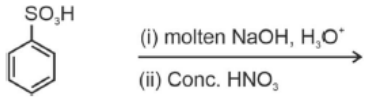
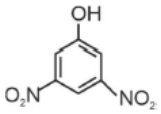
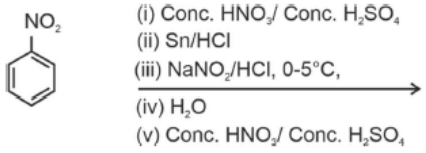
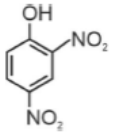
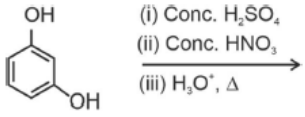
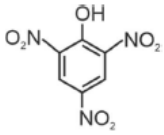
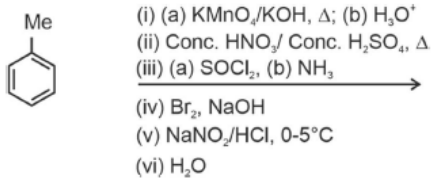
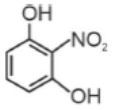
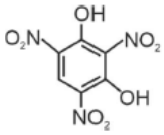

(R)
O
CH3
ethylene glycol
PTSA
CH3
a) Hg(OAc)2, H2O
b) NaBH4
OH
CH3
OH
NaBH4
O
CH3
OH
H3O+
CH3
OH

R-4


(S)
O
(i)ethylene glycol
PTSA
a) BH3, b) H2O2, NaOH
OH
OH
NaBH4
O
OH
H3O+
OH

S-1

17. List-I contains various reaction sequences and List-II contains different phenolic compounds. Match each entry in List-I with the appropriate entry in List-II and choose the correct option.

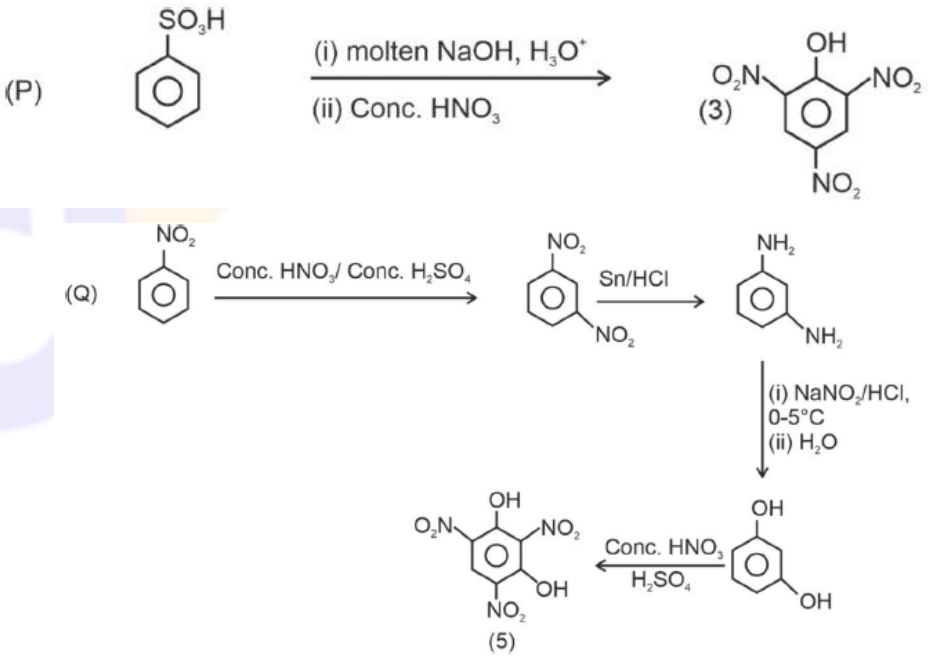
	List-I		List-II
(P)		(1)	
(Q)		(2)	
(R)		(3)	
(S)		(4)	
		(5)	

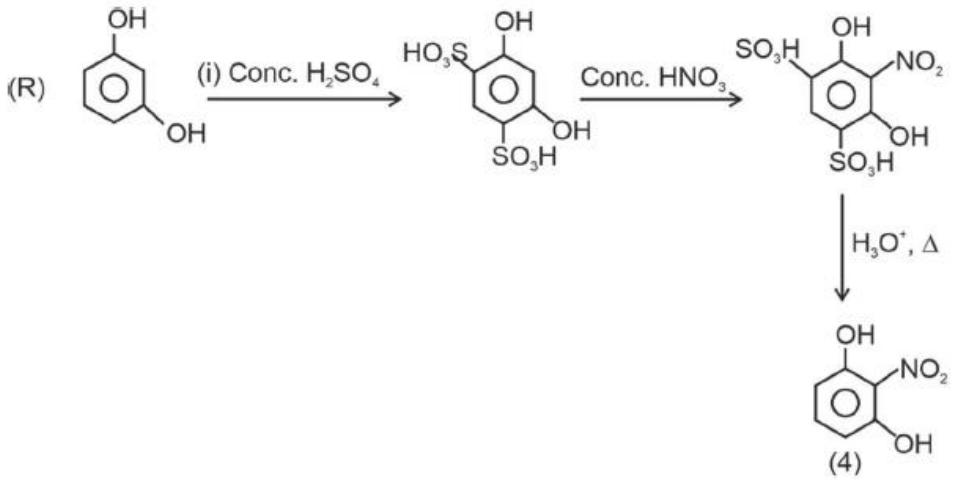
(A) P-2, Q-3, R-4, S-5 (B) P-2, Q-3, R-5, S-1

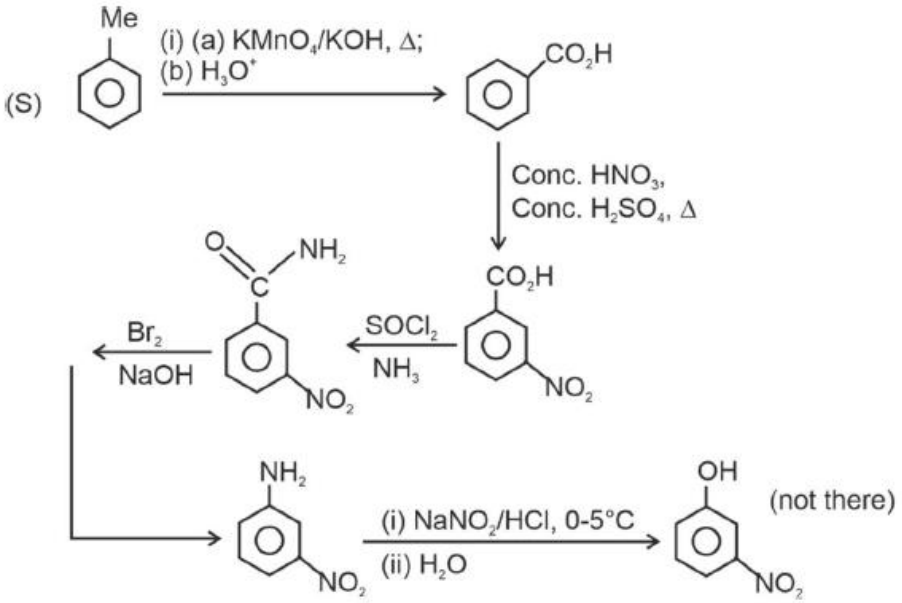
(C) P-3, Q-5, R-4, S-1 (D) P-3, Q-2, R-5, S-4

Ans. **(C)**

Sol.




(R)
OH
OH
(i) Conc. H_2SO_4
HO_3S
OH
OH
SO_3H
Conc. HNO_3
SO_3H
OH
NO_2
OH
SO_3H
H_3O^+, Δ
OH
NO_2
OH
(4)


(S)
Me
(i) (a) $KMnO_4$/KOH, Δ;
(b) H_3O^+
CO_2H
Conc. HNO_3,
Conc. H_2SO_4, Δ
CO_2H
NO_2
$SOCl_2$
NH_3
O
C
NH_2
Br_2
NaOH
NO_2
NH_2
NO_2
(i) $NaNO_2$/HCl, 0-5°C
(ii) H_2O
OH
NO_2
(not there)